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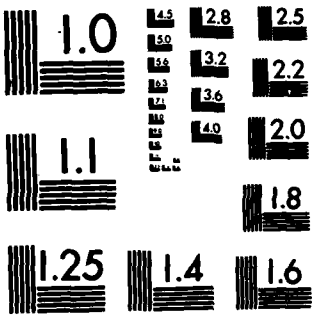

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RESEARCH ON NONLINEAR DYNAMICAL SYSTEMS

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Final Technical Report

U. S. Army Research Office

Grant DAAG29 76 G 0294

September 1, 1976 - August 31, 1979

Principal Investigator: Professor J. P. LaSalle

Grant DAAG29-79 C 0161

September 1, 1979 - September 24, 1982

Principal Investigators: H. T. Banks
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January 10, 1983

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ABSTRACT

This Final Technical Report summarizes research findings supported by Grants DAAG29 76 G 0294 (during period 9/1/76-8/31/79) and DAAG29 79 C 0161 (during period 9/1/79-9/24/82). The principal areas of research reported are:

1) Functional and partial differential equations and their control and estimation;
2) Hyperbolic systems of conservation laws;
3) Continuum physics;
4) Stability of nonlinear evolution equations;
5) Linear and nonlinear dynamical systems and their stability; and
6) Bifurcation theory.

This report briefly summarizes results and refers to specific publications and reports previously reported to the U. S. Army Research Office.

TABLE OF CONTENTS

I. Foreword

This is the Final Technical Report on the research project entitled Research on Nonlinear Dynamical Systems supported through Grants DAAG29 76 G 0294 during the period September 1, 1976 - August 31, 1979 and DAAG29-79 C 0161 During the period September 1, 1979 - September 24, 1982.

The focus of research in this project was in several inter-related areas: 1) Control and parameter estimation for delay and partial differential equations, 2) Qualitative theory including stability and bifurcation for delay and partial differential equations, and 3) Conservation laws and stability in continuum physics.

A brief summary of major research accomplishments and applications is reported in Section II. Each subsection, reporting on a research area, refers to reports or publications previously reported to the U. S. Army Research Office. These publications and reports are listed in Section III.

The final section reports the personnel supported from these grants.

II. Summary of Research Accomplishments and Applications

Banks and coworkers in [1-6,8-10,14-16]* deal with approximation methods for delay equations with applications to computational algorithms for optimal control and parameter estimation, including estimation of multiple delays in nonlinear systems. In [7,11-13,15,17-19,21,22] are found results for spline and modal approximation schemes for parabolic and hyperbolic systems of partial differential equations, including higher order equations of elasticity based on the Euler-Bernoulli and Timoshenko theories. The approximation ideas are applied to develop algorithms for estimation of parameters including unknown functional coefficients and boundary parameters.

Dafermos and coworkers have obtained [28],[34],[38] results pertaining to existence, smoothness, and asymptotic behavior of solutions to hyperbolic conservation laws. Results in continuum physics related to the role of the second law of thermodynamics in inducing admissibility, uniqueness, and stability of solutions can be found in [30-33], while the role of dissipation as a stabilizing mechanism that counterbalances the destabilizing effects of nonlinearity in evolution equations is investigated in [33,36,37,39,40].

Hale and his coworkers have investigated fundamental aspects of functional differential equations, including qualitative questions (stability, nonlinear oscillations), in [42,45,47,52-57,62,66,68,74]. Specific problems in nonlinear oscillations (subharmonics, homoclinic orbits, etc.) in ordinary differential equations are dealt with in [43,44,50,60,61,70,71] using bifurcation theory and averaging. General bifurcation theory and the change in

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* References refer to publications listed in Section III.

stability at bifurcation for finite and infinite dimensional dynamical systems is investigated in [46,48-51,58,59,63,64,69]. Finally, stability and bifurcation in parabolic partial differential equations is the focus of [64,65,67,72,73].

In addition to these broad ranges of activities by the principal investigators, a number of postdocs and visitors have investigated a diverse number of related topics which have been detailed in the previous progress reports and in the references found in the next section.

III. Publications supported by ARO Grant DAAG29 76 G 0294 during period September 1, 1976 - August 31, 1979, and by Grant DAAG29-79 C 0161 during period September 1, 1979 - September 24, 1982. Copies of all publications have been previously sent to the Army Research Office and are numbered below as references to Section II.

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Personnel

1. Faculty Personnel

The following faculty personnel were partially supported by Grant #DAAG29 76 G 0294 during the period 9/1/76 - 8/31/79:

Professor D. M. Dafermos

Professor Jack K. Hale

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2. Graduate Student Personnel

The following graduate students were partially supported by the above grant during this period:

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G. Fusco, Research Assistant

*J. M. Mahaffy, Research Assistant

*J. W. Palmer, Research Assistant

*D. C. Reber, Research Assistant

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L. Turyn, Research Assistant

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Personnel

1. Faculty Personnel

The following faculty personnel were partially supported by Grant #DAAG29 79 C 0161 during the period 9/1/79 - 9/24/82:

Professor H. T. Banks
Professor C. M. Dafermos

Professor Jack K. Hale

*Professor E. F. Infante

Professor J. P. LaSalle

Professor J. Mallet-Paret

* On leave of absence from Brown University for the period 9/1/79 - 8/31/80 and also for the period 9/10/81 - 8/31/82.

2. Graduate Student Personnel

The following graduate students were partially supported by the above grant during this period:

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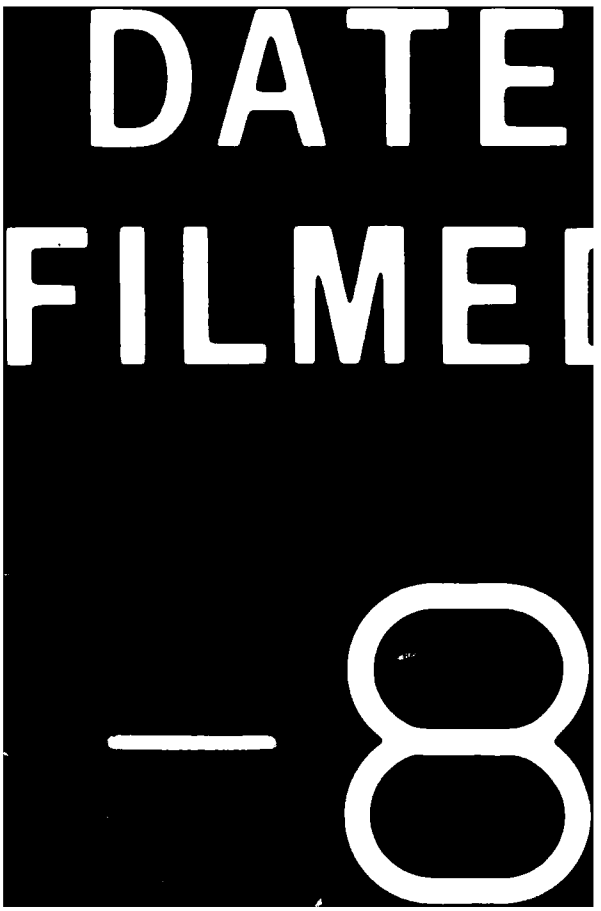
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